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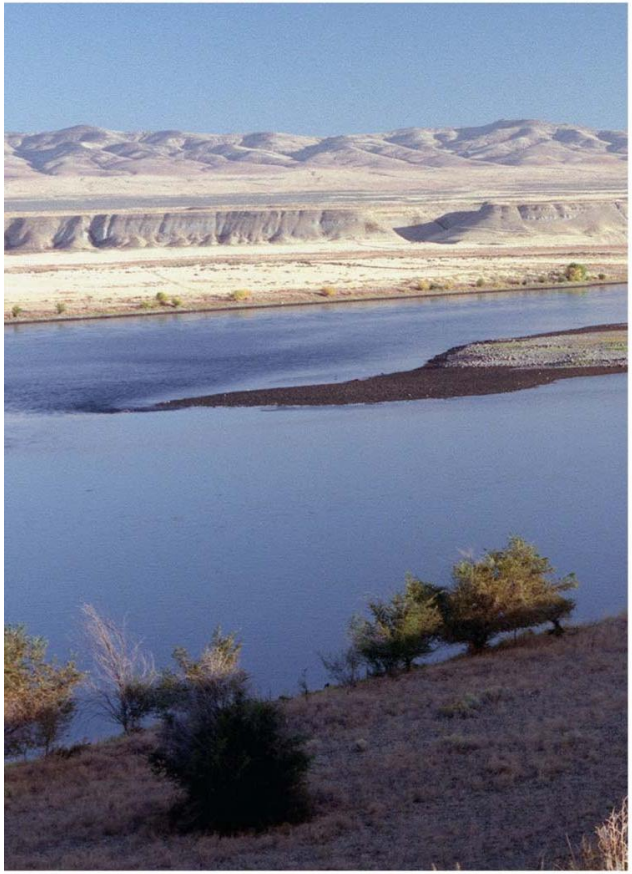

Deep Vadose Zone Remediation and Subsurface Access

U.S. DEPARTMENT OF ENERGY

Pacific Northwest NATIONAL LABORATORY

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Remediation Context

- Deep contaminants
  - Primary issue is the potential impact to groundwater
  - Difficult access for characterization, remediation, and monitoring
- Radionuclide contaminants (uranium, technetium)
  - not destroyed, so must manage for the long term

What do we know?

- Compilations of technology information
  - DOE. 1999. *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*.
  - Looney and Falta. 2000. *Vadose Zone, Science and Technology Solutions*.
  - CHG. 2007. *Central Plateau Vadose Zone Remediation Technology Screening Evaluation*.
  - DOE. 2008. *Deep Vadose Zone Treatability Test Plan for the Hanford Central Plateau*.
- Technology development and testing
  - DOE EM-32 program
  - Deep Vadose Zone Treatability Test

What are the options?

- Remove (excavation, soil flushing)
  - **extract**, stabilize/reduce volume, dispose
- Contain (surface barrier)
  - create physical barrier to minimize movement to groundwater
- In situ treatment (desiccation, in situ precipitation)
  - use subsurface process to minimize movement to groundwater
- Natural Attenuation

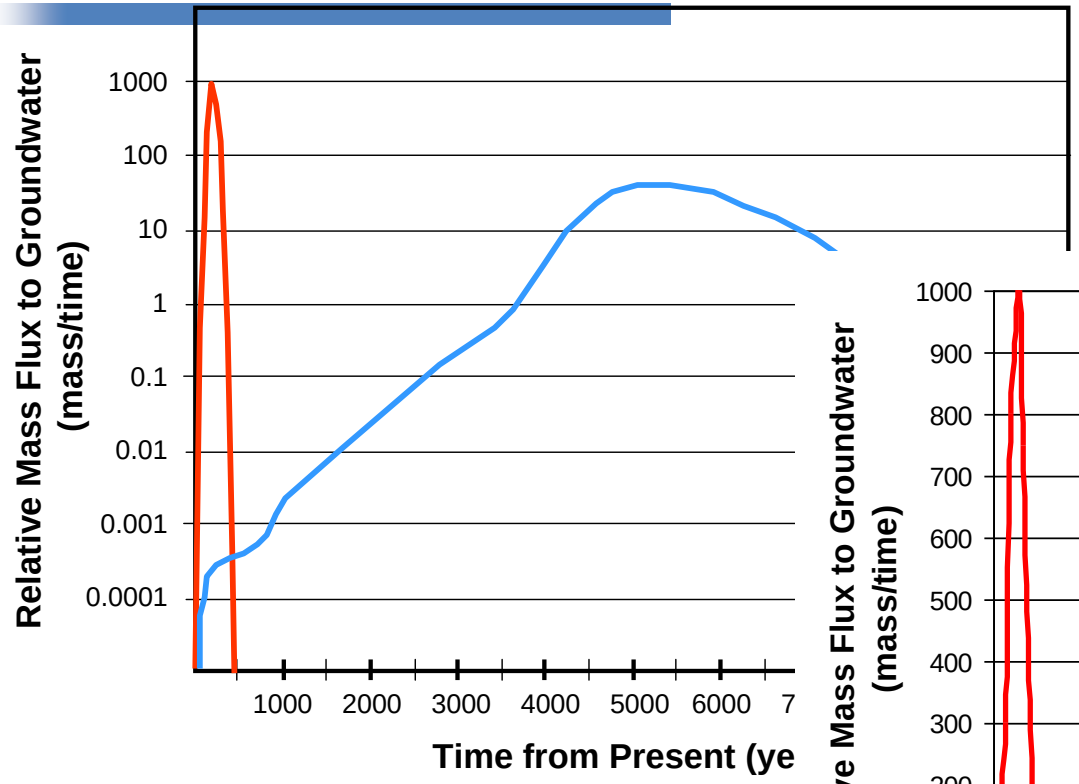
What does remediation do?

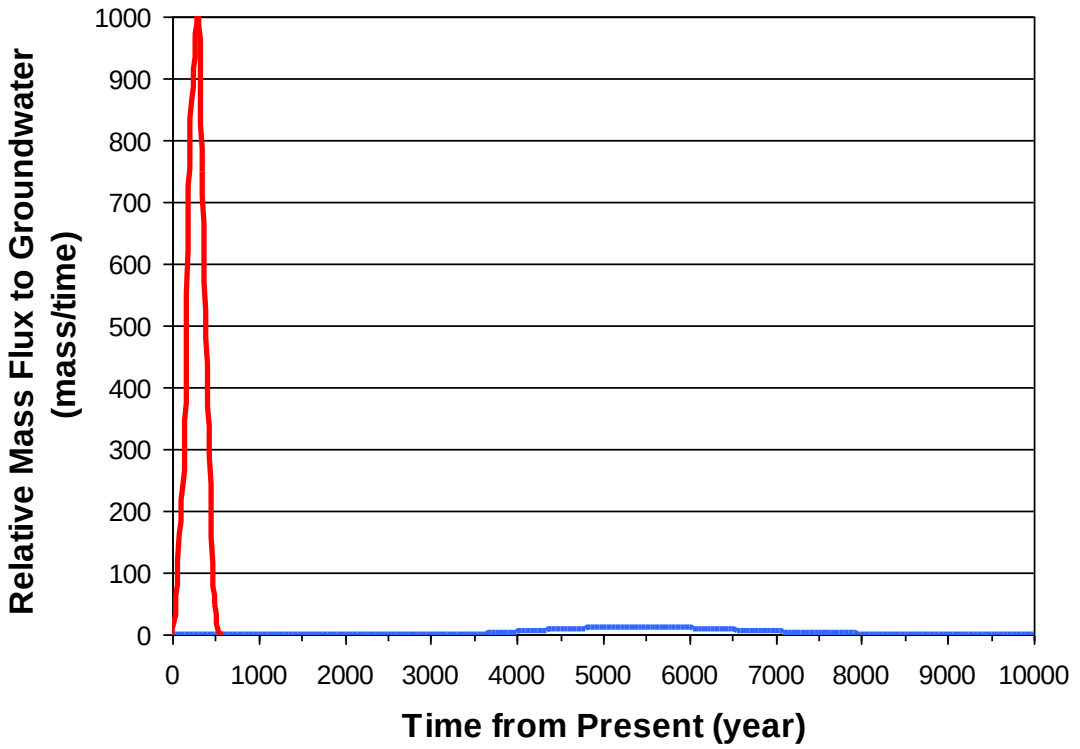
- End result: Reduced flux of contaminants to groundwater
  - if low enough, groundwater concentration stays low
- Remove
  - Remove enough contaminant to prevent threat to groundwater.
- Contain and in situ treatment
  - Slow the movement through the vadose zone.
- Natural Attenuation
  - Is the contaminant flux low enough already?

Linkage to "Characterize/Predict/Monitor" Elements

- How are the contaminants moving now and how much do we need to change this movement?

Conceptual Example of Flux Reduction





How do we remediate?

- Remove
  - Move contaminants to the surface
    - Excavate soil
    - Move water through soil, catch and carry contaminants in water, capture the water, and bring it to the surface

How do we remediate?

- Contain
  - Minimize movement of water through contaminated zone
    - Install a surface barrier to minimize infiltration into the subsurface

How do we remediate?

- In Situ Treatment
  - Distribute energy or materials in the subsurface to change the contaminant and/or subsurface conditions in a way that minimizes contaminant movement
    - Desiccate the soil to reduce the movement of water and associated contaminants through the vadose zone
    - Inject a reagent that causes contaminants to be bound in precipitates

Linkage to "Characterize/Predict/Monitor" Elements

- Where do we remediate?
- What is the physical and chemical setting for remediation?
- What is the impact of our action now and in the future?

What are we doing now?

- DOE EM-32 Program
  - In Situ Treatment of Metals and Radionuclides
    - Example activity: improved delivery of remediation amendments to the vadose zone (e.g., foam)
- Deep Vadose Zone Treatability Testing at Hanford

Deep Vadose Treatability Test Plan

- Evaluate specific vadose zone remediation technologies for technetium-99 and uranium
- Focus on in situ and surface barrier technologies
  - *In situ technologies for application to the Hanford deep vadose zone are not developed and tested sufficiently to enable an adequate evaluation as a remedial alternative. Thus, treatability testing is warranted.*

Deep Vadose Treatability Test Plan

Reviewed Technologies

Identified Technologies for Testing

Lab/Model/Field Testing of Gas-Phase Technologies

- desiccation of soil can reduce contaminant flux through vadose zone
- reactive gases can bind contaminants to reduce flux through vadose zone

Lab/Model Evaluation of Other Technologies

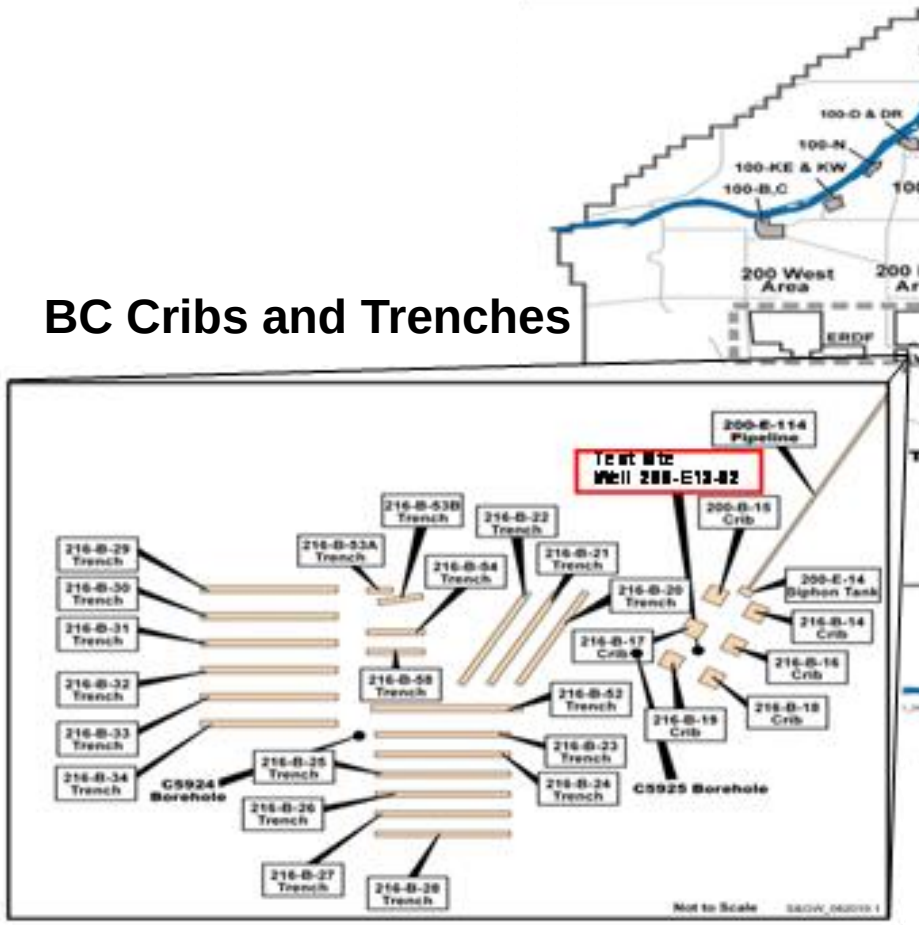
- surface barriers: how deep are they effective?
- soil flushing: can contaminants be effectively flushed through a 100-m-thick vadose zone and captured in the groundwater?
- in situ grouting: can grouting be effective in a deep heterogeneous vadose zone?

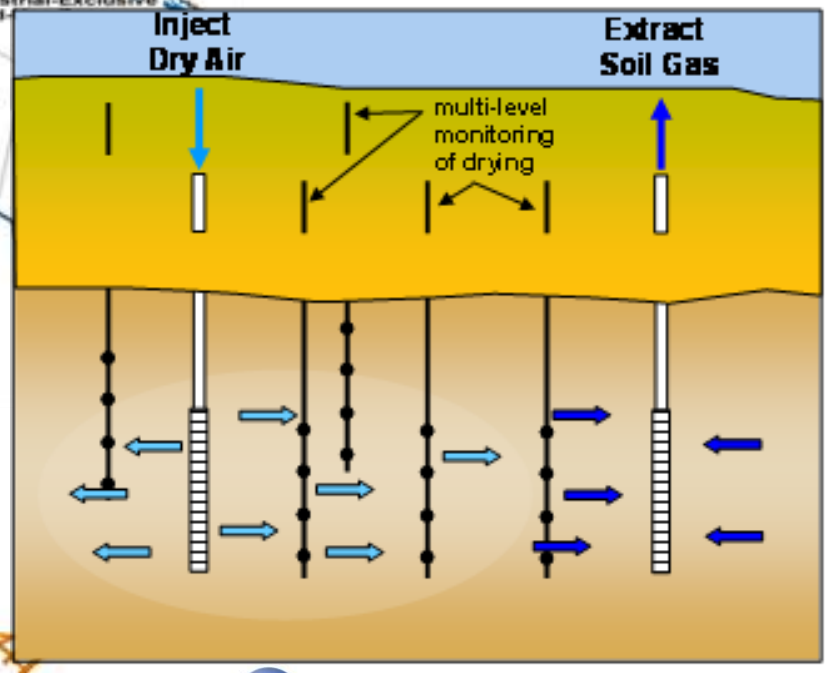
Desiccation Pilot Test

- Laboratory and modeling studies conducted 2008 through present
- Characterization test at field site completed in July 2009
- Scheduled to start desiccation test in October 2010

Desiccation Test

BC Cribs and Trenches



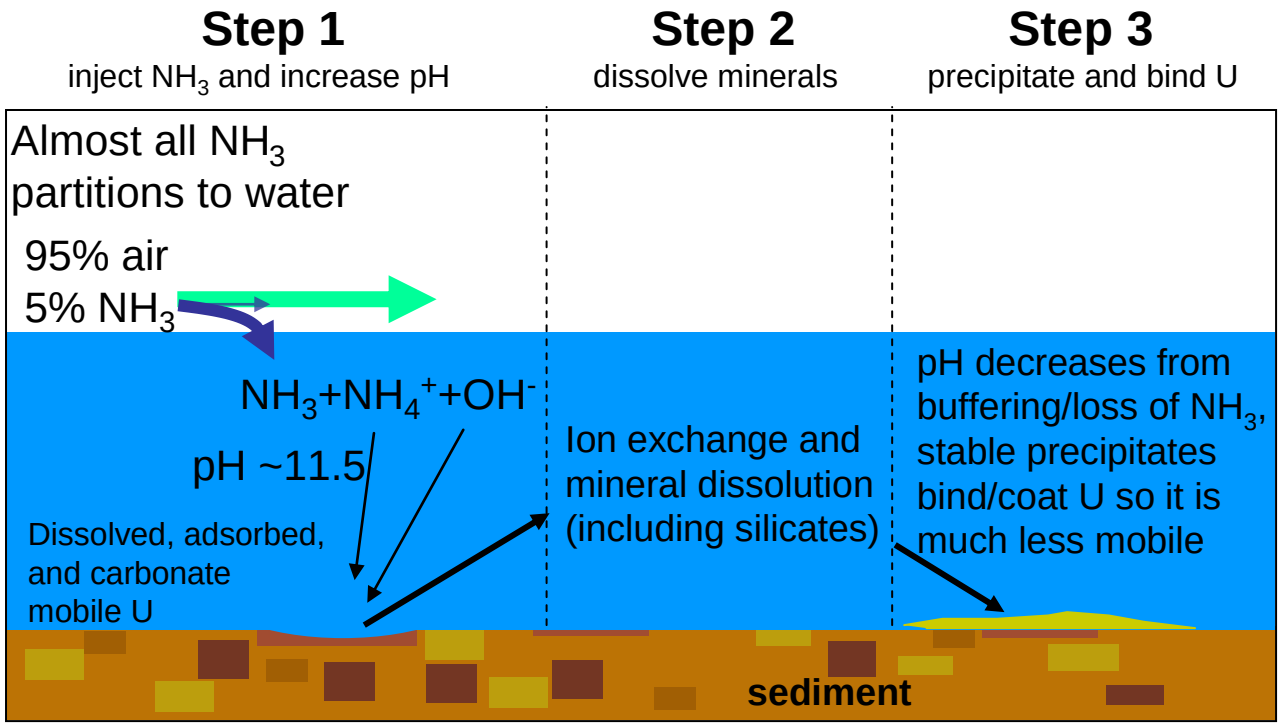


Reactive Gas Treatment of Uranium

- Laboratory evaluation of potential technologies conducted 2009 (SGW-44409)
- Laboratory study of selected ammonia gas technology initiated in 2010
- Field Test Plan to be developed 2011

Reactive Gas Treatment of Uranium

Ammonia Injection



Surface Barrier Study

- Surface Barrier Study
  - Evaluated existing published barrier reports to determine the effectiveness of barrier systems in context of deep vadose contaminants
  - Identified data gaps for deep vadose application
  - Results of study documented in PNNL-18661

Grouting and Soil Flushing

- Grouting Technologies
  - Initial evaluation underway in FY10
- Soil Flushing
  - Initial evaluation underway in FY10
- Potential for additional treatability tests to be added to program